User's Guide

C2000™ F280013x Series LaunchPad™ Development Kit

ABSTRACT

The LAUNCHXL-F2800137 is a low-cost development board for the Texas Instruments C2000™ Real-Time Microcontroller series of F280013x devices. The LAUNCHXL-F2800137 is designed around the TMS320F2800137 real-time MCU and highlights the control, analog, and communications peripherals, as well as the integrated nonvolatile memory. The LaunchPad™ Development Kit also features two independent BoosterPack™ XL expansion connectors (80-pins), on-board Controller Area Network (CAN) transceiver, one 5-V encoder interface (eQEP) connector, power-domain isolation, and an on-board XDS110 debug probe.

Figure 1-1 highlights the key features of the F280013x LaunchPad.

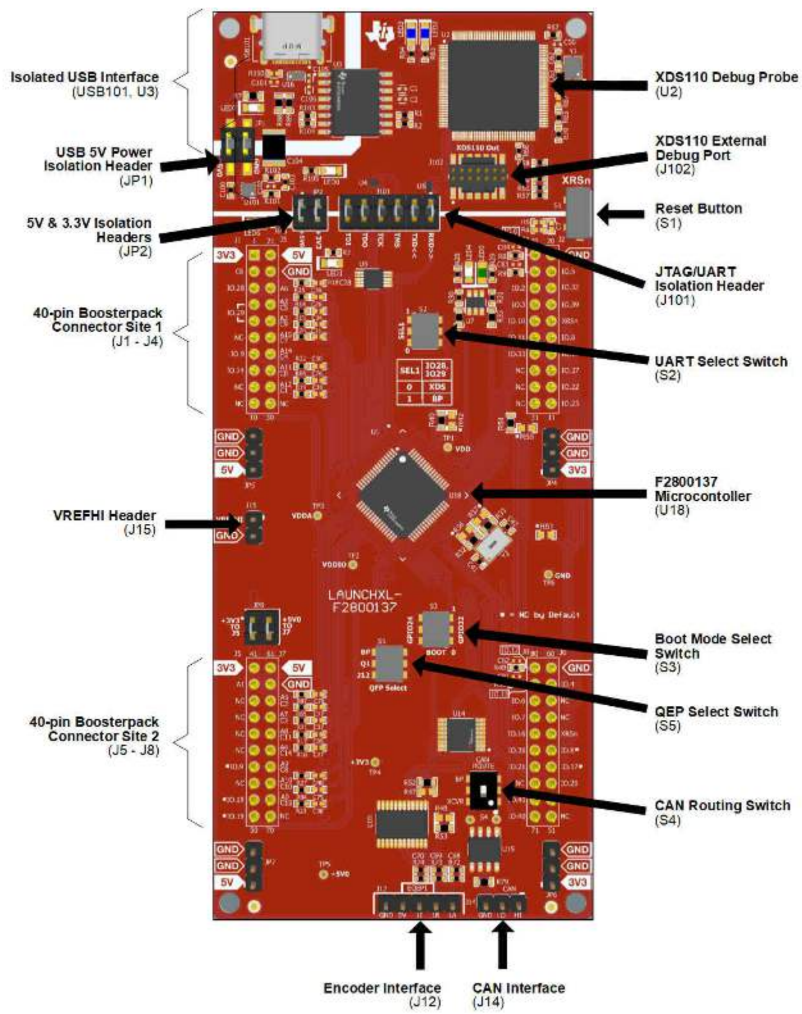

Figure 1-1. F280013x LaunchPad™ Board Overview

Table of Contents

List of Figures

List of Tables

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1 Board Overview

1.1 Kit Contents

The F280013x Series LaunchPad Development Kit contains these items:

- C2000 F280013x Series LaunchPad development board (LAUNCHXL-F2800137)
- USB Type-A male to USB Type-C™ male cable
- Pinout Map

1.2 Features

The F280013x LaunchPad has these features:

- C2000 Series F2800137PM (64-pin) Real-time Microcontroller
- On-board XDS110 debug probe
- Two user-controlled LEDs
- One microcontroller reset switch
- Selectable power domains:
  - USB (isolated)
  - BoosterPack
  - External power supply
- CAN connector with on-board CAN transceiver
- One independent Enhanced Quadrature Encoder Pulse (QEP)-based encoder connectors
- Two independent BoosterPack XL standard connectors (80-pins) featuring stackable headers to maximize expansion through the BoosterPack ecosystem

1.3 Specifications

Table 1-1 summarizes the F280013x LaunchPad specifications.

Table 1-1. LAUNCHXL-F2800137 Specifications

Parameter	Value
Board Supply Voltage	5 V_{DC} from one of the following sources: • USB Connector (USB101) - USB Type-C™ cable connected to PC or other compatible power source. • BoosterPack 1 • BoosterPack 2 • Auxiliary power connectors
Dimensions	5.5 in x 2.3 in x .425 in (13.97 cm x 5.84 cm x 10.8 mm) (L x W x H)
Break-out Power Output	3.3 V_{DC} to BoosterPacks, limited by output of TPS7A3701 LDO. This 3.3-V plane is shared with on-board components. Total output power limit of TPS7A3701 is 1 Amp.
Assumed Operating Conditions	This kit is assumed to run at standard room conditions. The EVM can run at approximately standard ambient temperature and pressure (SATP) with moderate-to-low humidity.

1.3.1 External Power Supply or Accessory Requirements

Nominal Output Voltage: *5 VDC*

Maximum Output Current: *3 A*

Efficiency Level V

Note

TI recommends using an external power supply or power accessory **that** complies with applicable regional safety standards such as (by example) UL, CSA, VDE, CCC, PSE, and so on.

1.4 Using the F280013x LaunchPad™

The recommended steps for using the F280013x LaunchPad are:

1. **Follow the instructions in Section 2.2 to begin running the LaunchPad demo program.** Within just a few minutes, you can control and monitor the F280013x LaunchPad with the pre-programmed quick start application. Additionally, the FAQ section included in this document can be helpful if there are any issues that can be quickly addressed.
2. **Experiment with BoosterPacks.** This development kit conforms to the latest revision of the BoosterPack pinout standard. This development kit has two independent BoosterPack sites to enable a variety of expansion opportunities, such as two booster packs being used simultaneously. For more information about the TI LaunchPad and BoosterPack standard, see the TI LaunchPad web page.
3. **Take the first step towards developing your own control applications.** The F280013x LaunchPad is supported by the C2000Ware development package. After C2000Ware is installed, look for \F280013x\examples\launchxl_F2800137 in the installation directory to find the pre-configured example applications for this board. Any of the other examples found within the \F280013x\examples directory can be used with minor modifications to run on the LaunchPad as well. For more details about software development, see Section 2.
   a. Check out the white paper on C2000™ F280013x Real-Time Microcontrollers applications, features, and benefits.
   b. Check out the technical article featuring C2000 Real-Time Microcontrollers about how developers can take advantage of the scalability and sustainability benefits these devices bring.
4. **Customize and integrate the hardware to align to your end application.** This development kit can be used as a reference for building your own custom boards and circuits based on C2000 F280013x series microcontrollers. The LaunchPad also functions as a foundation for expansion with custom BoosterPacks and other circuits. This document can serve as a starting point for such projects.
5. **Get Trained.** Review and download hours of written and video training materials on C2000 Real-time Microcontrollers and related LaunchPads.
   a. For more information, see the C2000 Real-Time Control MCUs - Support & Training page.
   b. See Getting Started with C2000™ Real-Time ControlMicrocontrollers (MCUs).

1.5 BoosterPack™ Plug-in Modules

The LAUNCHXL-F2800137 provides a simple and inexpensive way to develop applications with the F280013x series microcontroller. BoosterPacks are pluggable add-on boards for the LaunchPad ecosystem that follow a pin-out standard created by Texas Instruments. The TI and third-party ecosystem of BoosterPacks greatly expands the peripherals and potential applications that you can explore with the F280013x LaunchPad.

Some examples of BoosterPacks that are compatible with the F280013x LaunchPad are listed in Table 1-2. Please note that this is not an exhaustive list of hardware supported BoosterPacks.

Table 1-2. Featured BoosterPack™ Plug-in Modules for the F280013x LaunchPad™

BoosterPack/Board	Application and Usage
BOOSTXL-3PHGANINV	Features a 48-V/10-A three-phase GaN inverter with precision in-line shunt-based phase-current sensing for accurate control of precision drives such as servo drives.
BOOSTXL-DRV8323RS BOOSTXL-DRV8323RH	DRV8323RS/H Three-Phase, 15 A smart gate driver with buck, shunt amps (SPI or Hardware Interface) Evaluation Module.
DRV8353RS-EVM	15 A, 3-phase brushless DC drive stage based on the DRV8353RS gate driver and CSD19532Q5B NexFET™ MOSFETs.
DRV8316REVM	DRV8316REVM provides three half-H-bridge integrated MOSFET drivers for driving a three-phase brushless DC (BLDC) motor with 8-A Peak current drive, for 12-V/24-V DC rails or battery powered applications.
BOOSTXL-BUCKCONV	Digital Power Buck Converter BoosterPack for learning the basics of digital power control with C2000 microcontrollers. The buck converter power stage supports dynamic loads and converts an external 9-VDC power supply to a configurable DC output voltage.
BOOSTXL-POSMGR	Position Manager BoosterPack is a flexible low-voltage platform intended for evaluating interfaces to absolute encoders and analog sensors like resolvers and SinCos transducers.
BOOSTXL-SHARP128	Sharp® 128 x 128 Memory LCD and microSD Card BoosterPack, controlled using SPI. Display sensor readings, time, graphics, or other information using the LCD screen.

Note

Software support for the BoosterPack plug-in modules and boards listed varies.

Users can also design their own BoosterPacks for the F280013x LaunchPad. Make sure that compatibility requirements are met by referencing the signal pin mapping in LAUNCHXL-F2800137 Pin Mapping (SPRUJ33) or schematic.

1.6 Hardware Revisions

This section contains an abbreviated revision history of the LAUNCHXL-F2800137 as well as known issues with each revision.

1.6.1 Revision A

The first production revision of the LAUNCHXL-F2800137 was released near the end of 2022. This revision can be identified by the "MCU109A" silkscreen labeling on the back side of the EVM between the BoosterPack Connector site 1 towards the top of the board.

Issues and concerns that have been identified on the EVM are listed below:

Known issues:

- No issues to report at this time of initial release.

Special notes and considerations to be aware of:

- Nothing to report at this time of initial release.

2 Software Development

This section provides general information about software development, as well as instructions for programming the LaunchPad. Software tools and packages for C2000 real-time controllers, like the F280013x, are listed in the C2000 Evaluation & Development page.

2.1 Software Tools and Packages

Code Composer Studio™ (CCS) is a free integrated development environment (IDE) that supports TIs Microcontroller and Embedded Processors portfolio. The CCS IDE provides a feature rich environment for developing, programming, and debugging code on the C2000 family of MCUs.

C2000WARE is a repository of device-specific drivers, bit-field support files, libraries, peripheral examples, utilities, hardware files, and documentation for C2000 MCUs. C2000WARE provides a solid foundation to begin development and evaluation of the F280013x device on the LAUNCHXL-F2800137 and minimize software development time.

Software Development Kits (SDKs) are provided to make evaluating C2000 MCUs within specific system use-cases easier and reduce overall development time. The Motor Control SDK (C2000WARE-MOTORCONTROL-SDK) is targeted for various motor control applications, such as industrial drives. The Digital Power SDK (C2000WARE-DIGITALPOWER-SDK) is targeted for digital power system development for various AC-DC, DC-DC, and DC-AC power-supply applications.

2.2 F280013x LaunchPad™ Demo Program

The LAUNCHXL-F2800137 includes a TMSF2800137PM device pre-programmed with a demo program in flash memory. When the LaunchPad is powered on the demo program begins with an LED blink sequence on LED4 and LED5. After a few seconds the device switches into an ADC sampling mode.

Every 1 second the ADC samples pin ADCINA6 and the sampled value is represented as follows:

- If the sample is above mid-scale (2048), the red LED4 illuminates.
- If the sample is below mid-scale, the green LED5 illuminates.

In addition to the LED indicators, ADC sample results are also displayed on your PC through the USB/UART connection. To view the UART information on your PC, first determine the COM port associated with the LaunchPad. To do this in Windows open the *Device Manager*. Look for an entry under Ports (COM & LPT) titled "XDS110 Class Application/User UART (COM***X***)", where ***X*** is a number. Remember this number for when you open a serial terminal.

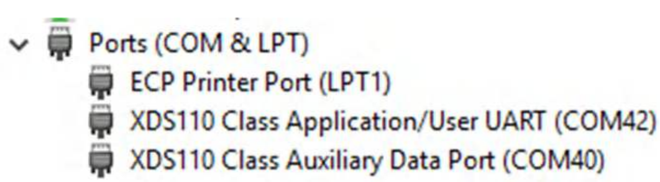

Figure 2-1. LaunchPad™ XDS110 COM Port

The demo application's UART data was tested using PuTTY, which is a free and open-source terminal emulator. To view the UART data in a serial terminal program, open the COM port found using the Windows *Device Manager* with the following settings:

```
115200 Baud, 8 data bits, no parity, 1 stop bit.
```

After properly opening the serial port in your serial terminal, reset the LaunchPad by pressing the S1 reset button and observe the serial terminal to see the TI logo in ASCII art (Figure 2-2).

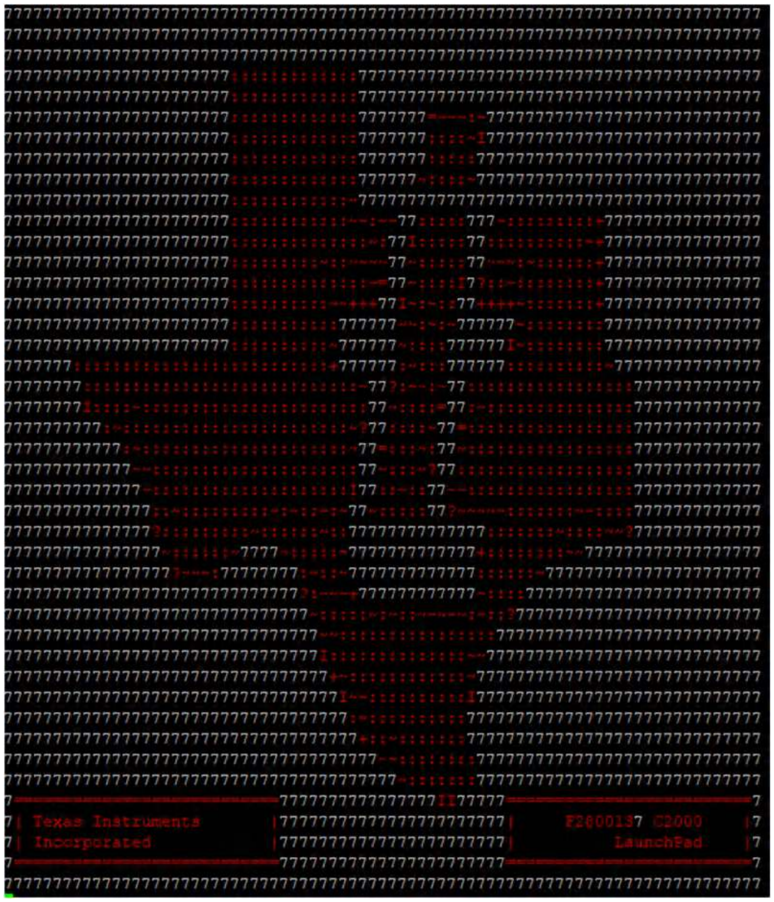

Figure 2-2. LaunchPad™ Demo Serial Terminal - TI Logo

After a few moments, the ADC value sampled on the ADCINA6 pin appears in the bottom right corner of the terminal and is updated each second. Using a jumper wire, connect the ADCINA6 header to a 3.3 V, GND, or other 0-3.3 V signal to see the on-screen value change.

Figure 2-3. LaunchPad™ Demo Serial Terminal - ADC Sampling

2.3 Programming and Running Other Software on the F280013x LaunchPad™

The software packages described in Section 2.1 include example projects that can be loaded and run on the F280013x LaunchPad. If you installed the C2000WARE software to the default installation path of *C:\ti\c2000\C2000Ware_<version>*, you can find driverLib based example applications in *C:\ti\c2000\C2000Ware_<version>\examples\F280013x*. The on-board XDS110 is used with the On-Chip Flash Programmer tool to program applications to the F280013x LaunchPad.

Follow these steps to program example applications onto the F280013x LaunchPad development kit using the on-board XDS110 debug probe:

1. Install Code Composer Studio IDE on a PC running Microsoft Windows.
2. Connect the USB-A cable plug in to an available USB port on the PC and plug the USB Type-C™ plug to the port (USB101) on the F280013x LaunchPad.
3. Verify the following LEDs are illuminated:
   a. LED7, at the top left of the board, indicating 5-V USB power
   b. LED0 indicating 3.3-V power to the XDS110 debug probe
   c. LED1 indicating 3.-V power to the F2800137 MCU
4. Install Windows XDS110 and Virtual COM Port drivers, if prompted. Installation instructions are found in the XDS110 Product Page.
5. Run Code Composer Studio IDE on the PC.
6. Import a F280013x project from C2000WARE, or another installed software package, into the Code Composer Studio IDE workspace.
7. Add the *_LAUNCHXL_F2800137* predefined symbol to the imported DriverLib example project for the software to use relevant F280013x LaunchPad signal definitions.
   a. Open the projects Properties → Expand the *Build* tab → Expand the *C2000 Compiler* tab → Select *Predefined Symbol* → Add *_LAUNCHXL_F2800137* predefine NAME
8. Right-click the project name and select *Rebuild Project* in the Code Composer Studio IDE.
9. Launch the LAUNCHXL-F2800137 Target Configuration file and connect to the F280013x device. Make sure that the Target Configuration file is configured to use the 2-pin cJTAG advanced configuration. See FAQ section for additional details.
10. Click 'Load Program' and select the program's binary to load. The binary is loaded onto the device and can now be run and debugged.

3 Hardware Description

The F280013x LaunchPad includes a F2800137PM MCU, which is designed for advanced real-time control systems in cost-sensitive applications. A large number of these peripherals are made available to users by way of the on-board accessories and the BoosterPack connectors. This section explains how those peripherals operate and interface to the MCU.

Figure 3-1 shows a high-level block diagram of the F280013x LaunchPad.

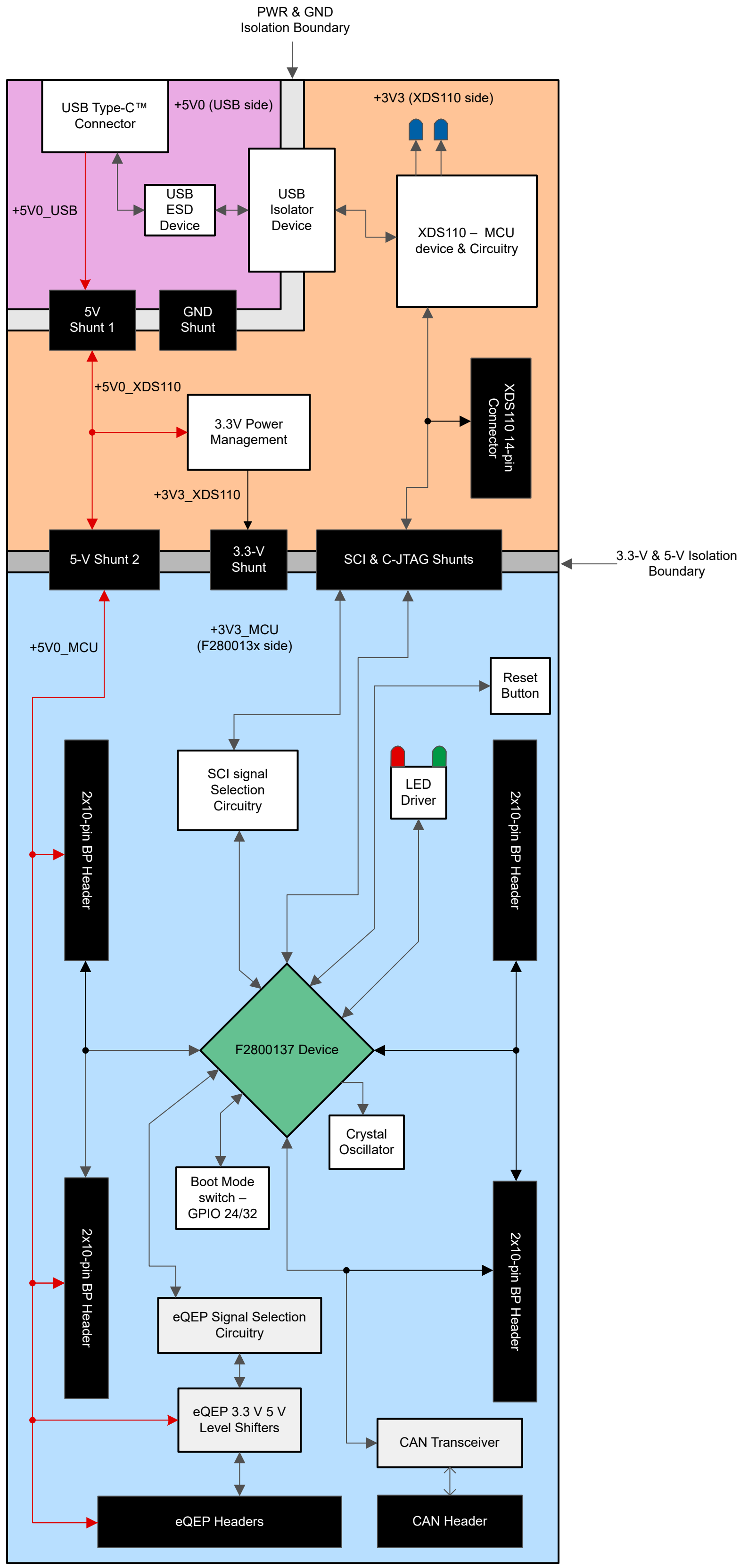

Figure 3-1. F280013x LaunchPad™ Development Kit Block Diagram

3.1 Functional Description and Connections

3.1.1 Microcontroller

The TMS320F2800137PM is a 32-bit floating-point microcontroller with 256KB Flash memory, 36KB RAM, and operates at 100 MHz. The microcontroller includes advanced control peripherals, differentiated analog, and various communications peripherals. The device has been optimized for high-performance, real-time control applications and offers a low-cost system solution. For more details, see *TMS320F280013x Real-Time Microcontrollers*.

Most of the microcontroller signals are routed to 0.1 inch (2.54 mm) pitch headers laid out to comply with the TI BoosterPack standards, with a few exceptions. The F280013x MCU internal multiplexers allow for different peripheral functions to be assigned to each of the general-purpose input/output (GPIO) pins. The mux options can be found in *TMS320F280013x Real-Time Microcontrollers*. When adding external circuitry, consider the additional load on the development board's power rails.

The F280013x LaunchPad is factory-programmed with a quick start demo program. The quick-start program resides in the on-chip Flash memory and executes each time power is applied, unless the application has been replaced with a user program. See Section 2.2 for details on the LaunchPad demo program.

3.1.2 Power Domains

The F280013x LaunchPad has several power domains that can be connected or isolated from each other with removable shunts. The different 3.3-V and 5-V power domains are described in Figure 3-2 and Figure 3-3.

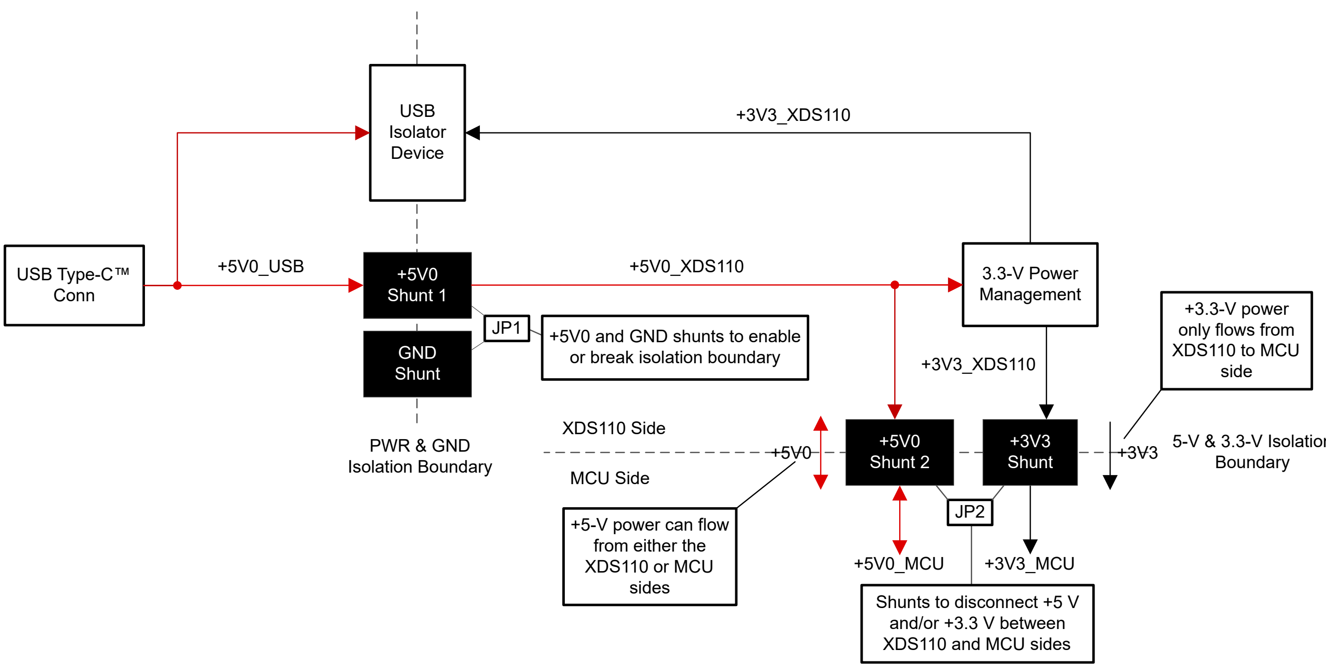

Figure 3-2. LaunchPad™ Power Distribution Diagram

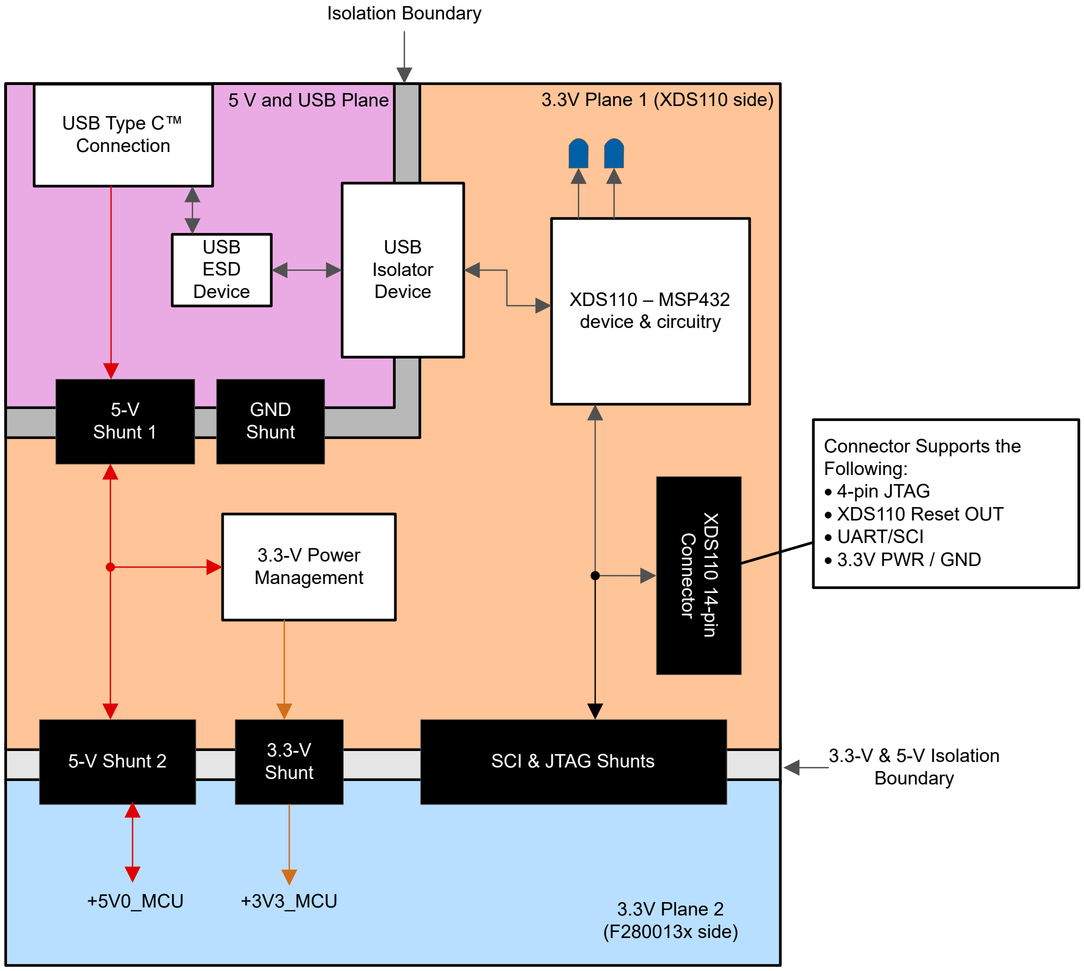

Figure 3-3. LaunchPad™ Power Plane Diagram

Table 3-1 describes the usage of the different removable shunts on the LaunchPad board.

Table 3-1. Power Domain Shunts

Shunt Indentifier	Usage Description
JP1, +5V0	Connects the +5-V power from the USB-C connector (+5V0_USB) to the +5-V power on the XDS110 side of the board (+5V0_XDS110). Bridges the power and ground isolations between the two board sides.
JP1, GND	Connects the board Ground on the isolated USB-C connector side of the board (USB_GND) to the rest of the board ground (GND). Bridges the power and ground isolations between the two board sides.
JP2, +5V0	Connects the +5-V power on the XDS110 side of the board (+5V0_XDS110) to the +5-V power on the F2800137 side of the board (+5V0_MCU).
JP2, +3V3	Connects the +3.3-V power on the XDS110 side of the board (+3V3_XDS110) to the +3.3-V power on the F2800137 side of the board (+3V3_MCU).

3.1.3 LEDs

Power indicator LEDs (red) are included on the F280013x LaunchPad board. See Table 3-2 for descriptions of each LED.

Table 3-2. Power LED Indication Descriptions

LED#	Indication Description
LED7	+5 V power from the USB Type-C™ connector
LED0	+3.3 V power on the XDS110 side of the PCB
LED1	+3.3 V power on the F280013x side of the PCB
LED6	+5 V power on the F280013x side of the PCB

Two user LEDs are provided on the board: LED4 (red) and LED5 (green). These user LEDs are connected to GPIO20 and GPIO22 of the F2800137, respectively. The signals are connected to the SN74LVC2G07DBVR LED driver IC and are connected in an active-low configuration; that is, drive the GPIO low to turn on the LED and high to turn the LED off. These LEDs are dedicated for use by the software application.

Two blue LEDs, LED2 and LED3, are connected to the XDS110 debug probe. These indicate debugger activity and are not controllable by any application software.

3.1.4 Encoder Connectors

The F280013x LaunchPad includes headers on J12 which are used for connecting a linear or rotary incremental encoder. These headers take 5 V input signals that are stepped down to 3.3 V and wired to the F2800137 MCU. These signals are connected to the eQEP modules on the device when switch S5 is set appropriately, see Table 3-5. The headers have the EQEPA, EQEPB, and EQEPI signals available for the single eQEP module as well as pins for GND and 5 V.

3.1.5 CAN

The F280013x LaunchPad includes a connector (J14) for a CAN network. GPIO4 and GPIO5 are routed from the F2800137PM to J14 through the on-board CAN Transceiver. Switch S4 is used to route GPIO4 and GPIO5 to either the CAN transceiver and connector or the boosterpack headers, see Section 3.3.4 for more details.

3.1.6 Boot Modes

The F2800137 boot ROM contains bootloading software that executes every time the device is powered on or reset. Two pins, GPIO24 and GPIO32, are wired to the Boot Select switch (S3), see Table 3-3. By default, both pins are set high (1) so the device boots from Flash. For more information on the F280013x boot modes, see *TMS320F280013x Real-Time Microcontrollers*.

Table 3-3. Boot Select Switch Table - S3

BOOT MODE	GPIO24 (LEFT)	GPIO32 (RIGHT)
Boot from Parallel GPIO	0	0
Boot from SCI / Wait boot	0	1
Boot from CAN	1	0
Boot from Flash (default)	1	1

3.1.7 BoosterPack™ Sites

The F280013x LaunchPad features two fully independent BoosterPack XL connectors. Both BoosterPack sites 1 and 2 are compliant with the BoosterPack standard, however many pins are left unconnected to the F280013x device because of the low pin-count. To expand the functions available to the user on this LaunchPad, some signals are also routed to alternate locations on the board. These alternate routes can be selected by manipulating the on-board switches or by adding or removing 0-ohm resistors. This is described in Section 3.3.

The GPIO pin numbers as well as the BoosterPack compliant features can be viewed in the LAUNCHXL-F2800137 Pin Mapping (SPRUJ33). Each GPIO has multiple functions available through the F280013x device's GPIO mux. Some specific functions have been listed in the Pin Mapping document; the full GPIO mux table can be found in *TMS320F280013x Real-Time Microcontrollers*.

All of the analog signals (denoted ADCIN) of the F280013x MCU are routed to the J1/J3 and J5/J7 BoosterPack headers on the left side of the board. Close to the respective BoosterPack header, each ADC input signal has component pads for a series resistor and parallel capacitor to create an RC filter. By default, a 0-ohm resistor is populated and the capacitor is left unpopulated. Users can wish to populate these components with specific values to filter out noise arriving at the device ADC input.

3.1.8 Analog Voltage Reference Header

The analog subsystem of the F280013x allows for flexible voltage reference sources. The ADC modules are referenced to the VREFHIx and VREFLOx pin voltages. VREFHIx can either be driven externally or can be generated by an internal bandgap voltage reference. An external voltage can be supplied to header J15 as an external voltage source for VREFHIx. Note that there is no signal conditioning circuitry in place for the voltage reference. For best performance, some additional circuitry may be required.

3.1.9 Other Headers and Jumpers

The LaunchPad has multiple jumpers to select different power sources for the board. This LaunchPad also provides a way to isolate the connected USB from the device, allowing for safe operation and debugging in higher voltage applications.

3.1.9.1 USB Isolation Block

JP1 is provided to enable isolation between the device and the connected USB in higher-voltage applications. The area of isolation is defined by the white outline in the upper-left corner of the LaunchPad. JP1 has two removable shunts to separate the GND and 5-V power of the USB region, and the XDS110 and F280013x MCU region of the LaunchPad. By default, both shunts are populated and the power is supplied by the connected USB, meaning that the USB is not isolated from the XDS110 and F280013x MCU regions. If power isolation is desired, remove the supplied shunts from JP1. In this configuration, one of the two external power options are required:

- An external 5-V supply to power the 3.3 V LDO (TPS7A3701), which provides 3.3 V to the XDS110 and F280013x MCU regions of the board.
- An external 3.3-V supply to power the XDS110 and F280013x MCU regions of the board.

Some applications do not require 5 V to be supplied to the MCU region. In an isolated power application with JP1 shunts removed, supplying 5 V to the XDS110 and F280013x MCU regions is optional.

3.1.9.2 BoosterPack™ Site 2 Power Isolation

JP8 is included to isolate 3.3 V and 5 V from the BoosterPack site 2 headers. This can be required if two BoosterPacks are simultaneously connected to the LaunchPad and both provide power to the LaunchPad. If this is the case, power can be isolated by removing the shunts on JP8 and there is no contention between the two BoosterPacks.

3.1.9.3 Alternate Power

Additional jumpers are provided outside of the BoosterPack connector for additional external power connections for 3.3 V or 5 V. These can be used to supply an external board or for powering the LaunchPad with an external supply. When using these connection points, ensure that no other power supplies are connected.

- **JP4 and JP6** are provided as extra connection points for a 3.3 V supply to be connected to the LaunchPad.
- **JP5 and JP7** are provided as extra connection points for a 5 V supply to be connected to the LaunchPad.

3.2 Debug Interface

3.2.1 XDS110 Debug Probe

The F280013x LaunchPad includes an on-board XDS110 debug probe. The XDS110 allows for the programming and debugging of the F2800137 using the Code Composer Studio IDE or any other supported tool chains. In the default configuration, the XDS110 is only wired to support 2-pin cJTAG mode. This uses only the TMS and TCK JTAG pins and allows the TDI and TDO pins of the F280013x device to be reallocated for other application needs. TDI and TDO are available on GPIO35 and GPIO37. These pins are not routed to the debug probe by default, but can be connected by populating resistors R44 and R45.

3.2.2 XDS110 Output

The connector J102 is provided to debug an external target with the on-board XDS110 debug probe. This connector allows the LaunchPad to be used as a stand-alone XDS110 debug probe. For mating connector and cable, see Samtec FFSD or equivalent.

If the LaunchPad is being used in this manner, make sure that all of the jumpers are removed from J101. This isolates the JTAG signals from going to the F2800137 MCU. The UART TX and RX signals from the XDS110 device are also included on this connector.

3.2.3 Virtual COM Port

When plugged into a USB host, the XDS110 enumerates as both a debugger and a virtual COM port. J101 allows the user to connect the SCI UART from the F2800137 to the debug probe to be passed on to the USB host. By default the F280013x SCIA maps to the virtual COM port of the XDS110 using GPIO28 and GPIO29. This is accomplished by manipulating the on-board switch S2. For the appropriate switch settings, see Section 3.3.2.

3.3 Alternate Routing

3.3.1 Overview

The F2800137 MCU is a very versatile device in a small package. To balance compatibility with BoosterPack standards, as well as showcasing the versatility of the F2800137, some complexity was added to the design. Most features aligning with the BoosterPack standard are available by default. The additional functions are configured using switches or static resistors which can be added or removed. This section covers the alternate functions and how to enable them. Note that by enabling certain alternate features, standard BoosterPack functionality may be lost. The switches and resistors are configured such that it is not possible to connect multiple functions to the same header.

3.3.2 UART Routing

This LaunchPad allows for one set of pins to be used for the SCIA UART routed to the virtual COM port of the XDS110. By default, GPIO28 (SCIA_RX) and GPIO29 (SCIA_TX) are routed to the virtual COM port and not available on the BoosterPack connector. When UART functionality is not needed at the virtual COM port, the GPIOs can be routed to the BoosterPack connectors for BoosterPack standard functions. The routing destination of these signal pairs are selected using the on-board switch S2, as described in Table 3-4.

Table 3-4. SCI UART Select Table - S2

SEL1 (LEFT)	GPIO28/29
0 (Default)	XDS110 COM Port
1	BP Headers

3.3.3 EQEP Routing

The LaunchPad has the ability to connect to one independent linear or rotary encoder through the F280013x on-chip eQEP interface: Header J12 is connected to eQEP1. By default, this connection is not active and the GPIOs are routed to the BoosterPack connectors. The 5-V eQEP input signals from the J12 connector are stepped down through a TI SN74LVC8T245 Level Translator (U13) to 3.3V. The signals are then routed through TI SN74LV4053A Triple 2-Channel Analog Multiplexer/Demultiplexer IC (U14). Switch S5 controls the select inputs of the ICs to configure the eQEP signal destinations to be either the J12 connector or BoosterPack headers, as described in Table 3-5.

Table 3-5. QEP Select Table - S5

QEP1 SEL (LEFT)	QEP1 Signals (GPIO40/41/39)
0 (down)	J12
1 (up)	BP Headers

3.3.4 CAN Routing

The LaunchPad can be connected to a CAN bus through J14. GPIO4 and GPIO5 are routed to the on-board TI TCAN332DR 3.3V CAN Transceiver, U15. By setting S4 to DOWN (on), GPIO4 and GPIO5 are routed to the transceiver. If S4 is set to UP (off), the GPIOs are routed to the BoosterPack connectors (default case).

3.3.5 SPI Routing

On the LaunchPad, one set of F2800137 SPI signals are able to be routed to either site 1 or site 2, or both sites for cases using multiple boosterpacks with the SPI. The signal connections are able to be completed by populating 0-ohm resistors on the board. By default, the resistors are populated so that the SPI signals only go to the site 1 boosterpack headers. See the *SPI Routing* section of the LaunchPad's schematic to see the corresponding resistor circuitry.

Table 3-6. SPI to BoosterPack Resistors

GPIO	SPI Signal	Resistor	BP Header Connection
GPIO9	SPIA_CLK	R40	J1, pin 7
		R42 (DNP by default)	J5, pin 47
GPIO8	SPIA_SIMO	R54	J2, pin 15
		R55 (DNP by default)	J6, pin 55
GPIO17	SPIA_SOMI	R46	J2, pin 14
		R51 (DNP by default)	J6, pin 54

3.3.6 X1/X2 Routing

The F2800137 crystal oscillator output signal, X2, is multiplexed with GPIO18 and the crystal oscillator input, X1, is multiplexed with GPIO19. By default, the Launchpad uses an on-board crystal oscillator, Y2, as the clock source for the on-chip Phase-Locked Loop (PLL) that requires both X1 and X2 signals of the MCU. To balance the requirement of having cleanly routed oscillator signals and bringing all possible GPIOs to the BoosterPack connectors, both GPIO18/X2 and GPIO19/X1 can be routed to the BoosterPack connectors through 0-ohm resistors. If GPIO18 or GPIO19 are needed at the BoosterPack connectors, the on-chip zero-pin oscillators must be used as the clock source for the on-chip PLL. For more information on the X1/X2 configurations, see *TMS320F280013x Real-Time Microcontrollers*.

If GPIO18 functionality is needed at the BoosterPack Connector:

1. Remove R32 to separate GPIO18 from Y2.
2. Populate R36 to connect GPIO18 to the BoosterPack connector.

If GPIO19 functionality is needed at the BoosterPack Connector:

1. Remove R33 to separate GPIO19 from Y2.
2. Populate R37 to connect GPIO19 to the BoosterPack connector.

3.3.7 PWM DAC

The LaunchPad provides up to four PWM DAC signals at the BoosterPack headers using GPIO0 (BP pin 40) and GPIO1 (BP pin 39) on site 1 and GPIO12 (BP pin 80) and GPIO13 (BP pin 79) on site 2. The intended purpose of the PWM DAC signals is to utilize PWMs of the F280013x device as digitial-to-analog converters (DAC). This method involves low-pass filtering of the PWM signal to remove the high-frequency components and ideally leave only the DC component. See Using PWM as a DAC for more information.

By default, the RC filter is not populated. Instead, a 0-ohm resistor is populated and the capacitor is left unpopulated.

4 Board Design

The entire LAUNCHXL-F2800137 design files can be downloaded at this link: LAUNCHXL-F2800137 Design Files.

4.1 Schematic

The LaunchPad's schematic can be found at this link: LAUNCHXL-F2800137 Schematic.

4.2 PCB Layout

The layout source files for the LAUNCHXL-F2800137 are included in the design files and can be downloaded at this link: LAUNCHXL-F2800137 Design Files.

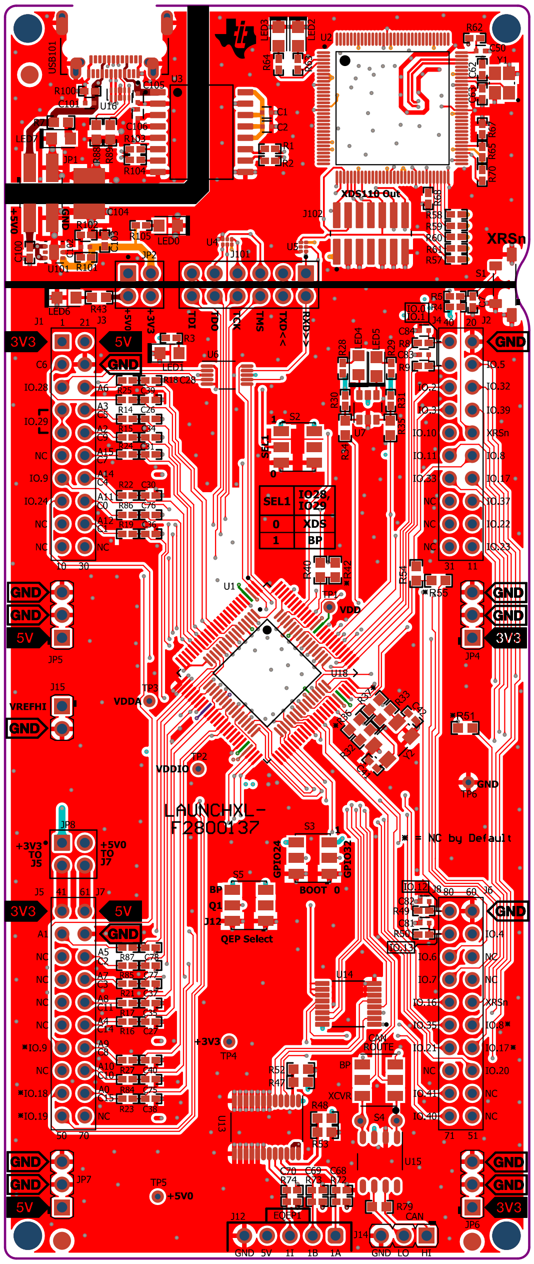

Figure 4-1. Top Signal - Layer 1

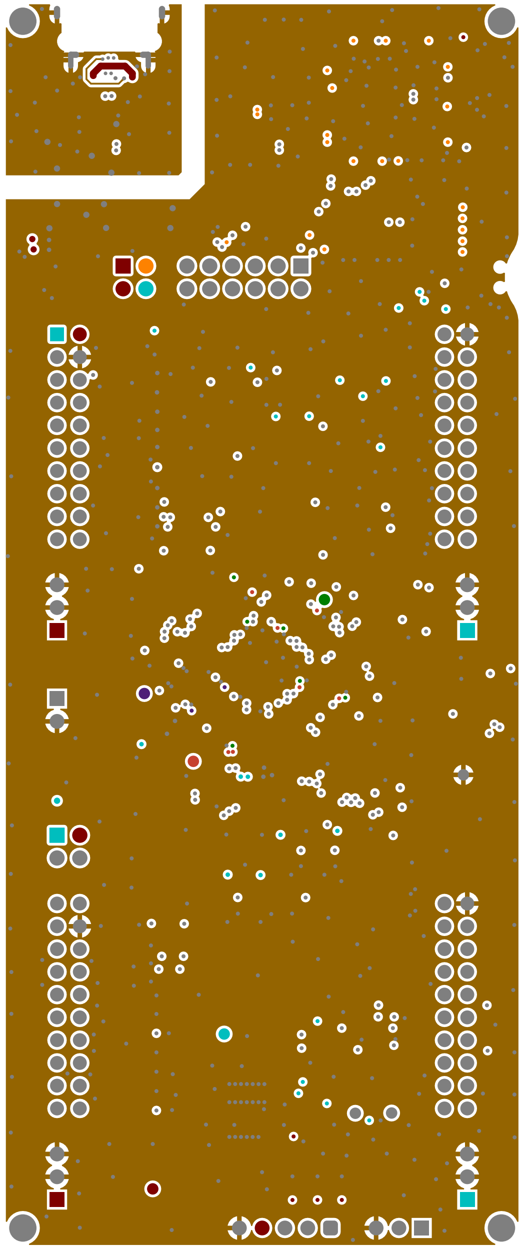

Figure 4-2. GND - Layer 2

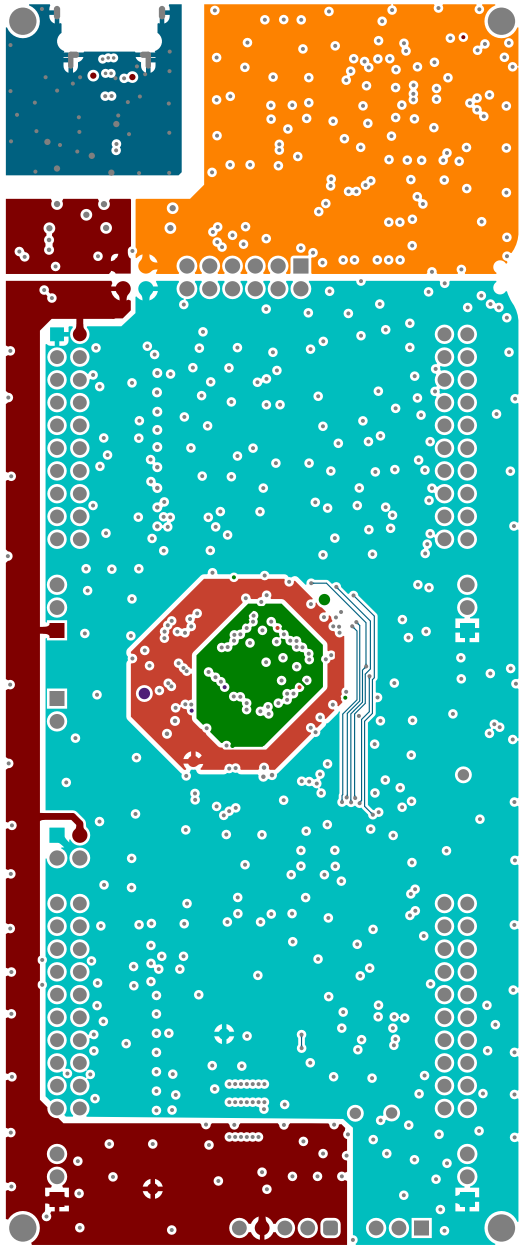

Figure 4-3. PWR - Layer 3

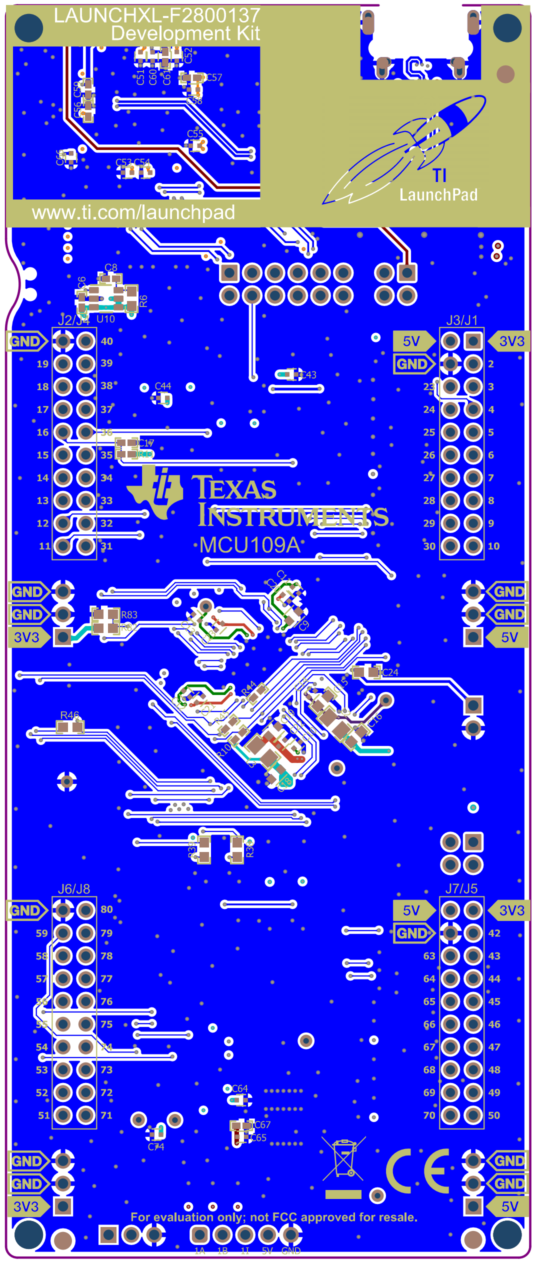

Figure 4-4. Bottom Signal - Layer 4

4.3 BOM

The BOM for the LAUNCHXL-F2800137 is included in the design files and can be downloaded at this link: LAUNCHXL-F2800137 Design Files.

4.4 LAUNCHXL-F2800137 Board Dimensions

Figure 4-5 is a dimensional drawing of the F280013x LaunchPad that shows the location of selected features of the board as well as the component locations.

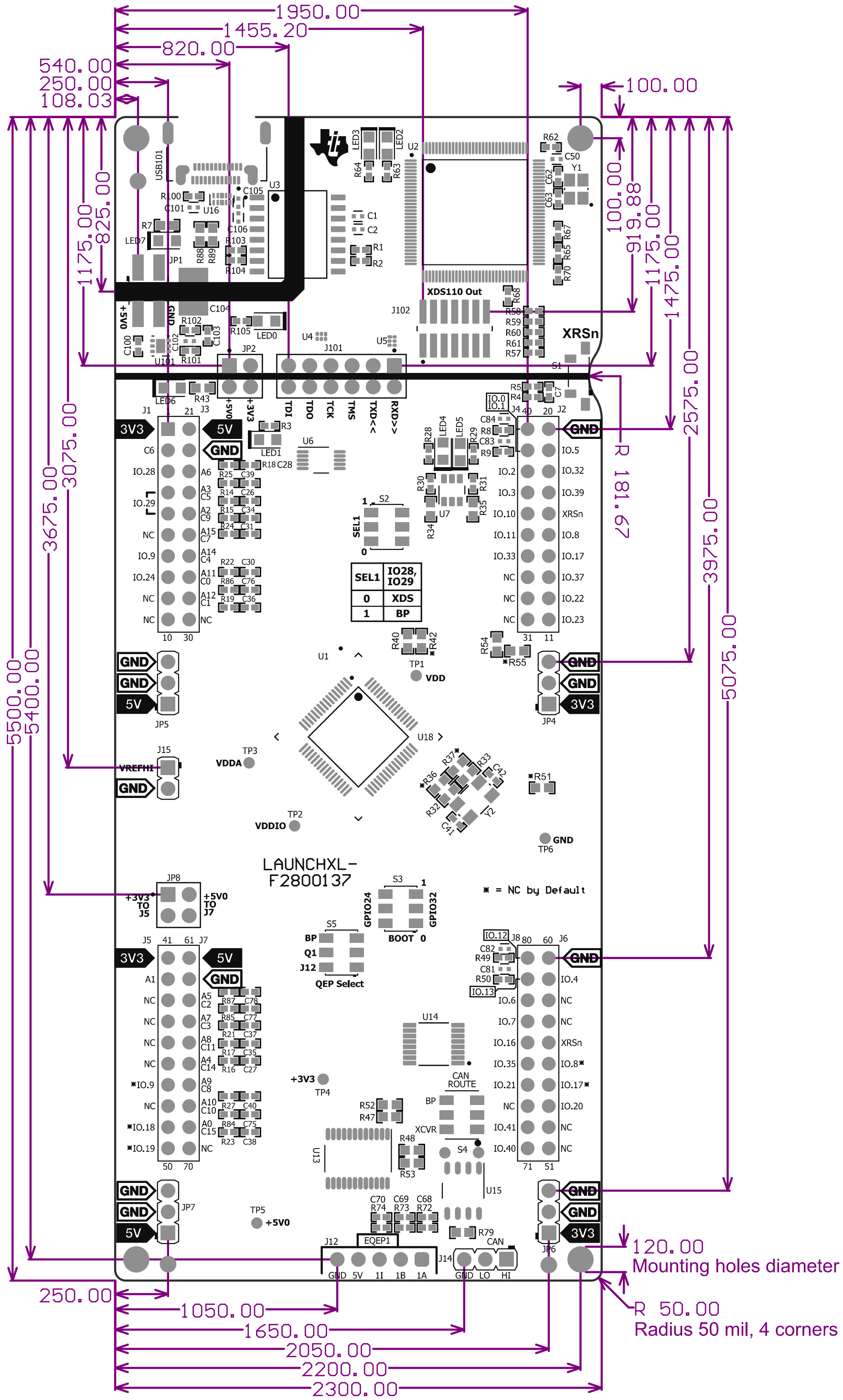

Figure 4-5. F280013x LaunchPad™ Dimensions and Component Locations

5 Frequently Asked Questions (FAQs)

1. Can other programming and debug tools (such as an XDS200 debug probe) be used with the F280013x LaunchPad?
   a. The F280013x LaunchPad utilizes an on-board XDS110 debug probe in a 2-pin cJTAG configuration. cJTAG only uses the TMS and TCK pins of the debug probe. TDI and TDO are present on tJ101 and can be connected to a debug probe through jumper wires, if necessary.
2. What versions of Code Composer Studio IDE can be used to develop software for the F280013x LaunchPad?
   a. The on-board XDS110 debug probe is compatible with Code Composer Studio IDE version 6.1.0 and later.
3. Why can't I connect to the LaunchPad in Code Composer Studio IDE?
   a. Are shunts present on J101 for TCK and TMS?
   b. Is the XDS110 and the F2800137 MCU powered? Are LED0 and LED1 illuminated? See Section 3.1.2 for further details on powering the LaunchPad.
      i. If JP1 shunts are disconnected, the power provided through the USB is isolated from the rest of the board. Make sure that 3.3 V is supplied to any of the available connectors on the target side of the isolation.
   c. Is the USB-C cable connected to the PCB and is the USB region receiving power? Is LED7 illuminated?
      i. The USB region must be powered with the 5 V from the USB cable. LED7 illuminates when 5-V USB power is connected. The USB isolation chip requires 5 V on the USB side to operate and pass the signals across the isolation barrier.
   d. Make sure that the target configuration is set up to use cJTAG in 2-pin advanced mode. Open the Target Configuration file (.ccxml) in the Code Composer Studio IDE. Click on the Advanced tab and select cJTAG (1149.7) 2-pin advanced modes from the drop-down labeled JTAG/SWD/cJTAG Mode. Leave the Target Scan Format as OSCAN2 format. Alternately, a working Target configuration file is included in the launcxl_ex1_F2800137_demo project "TMS320F2800137_LaunchPad.ccxml". You can use this without modifications.

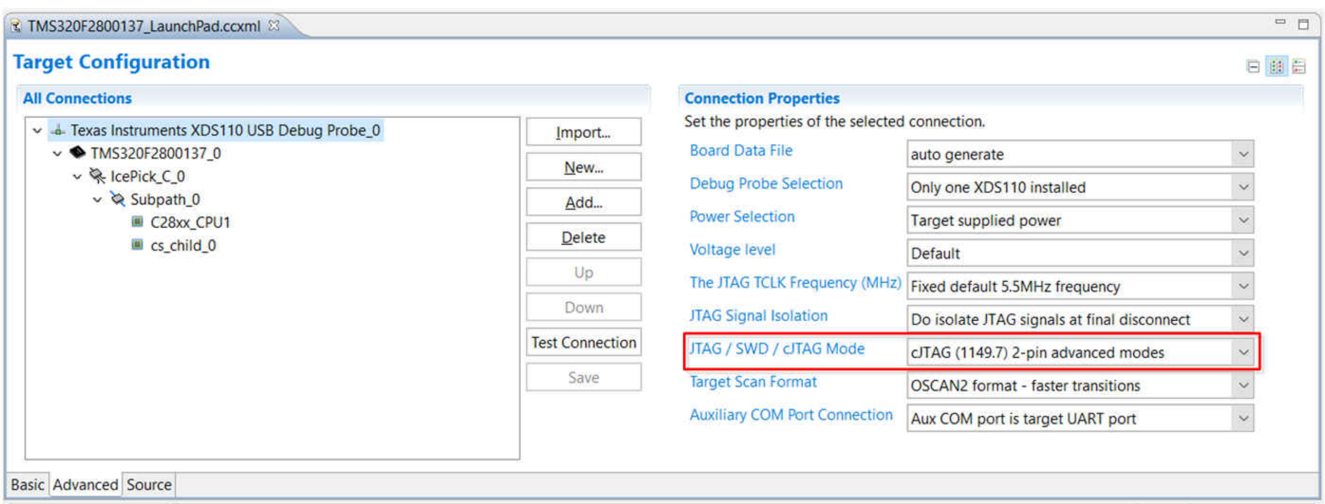

Figure 5-1. Target Configuration Advanced Options

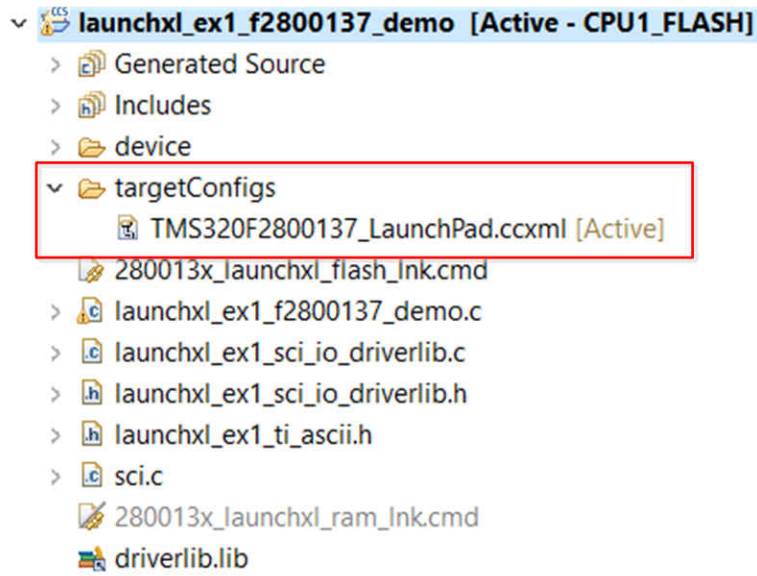

Figure 5-2. Target Configuration Included in the Demo Project

4. Why is the serial connection not working?
   a. Are shunts present on J101 for TXD and RXD?
   b. Are you using the correct COM port?
      i. Right click on My Computer and select Properties. Navigate to the Hardware tab in the dialog box and open the device manager. Scroll to Ports (COM and LPT) and expand this entry. Is XDS110 Class Application/User UART listed? If so, read the COM number to the right of the entry; this is the COM number you use.
   c. Are you using the correct baud rate? Most, if not all, of the examples are configured for a baud rate of 115200 when the CPU is running at 100 MHz. If you have changed the PLL settings or developed your own code, you have to recalculate the baud rate for your specific application. For information on how to do this, see the *TMS320F280013x C2000 Real-Time Microcontrollers Technical Reference Manual*.
   d. Does the UART channel wired to the debug probe match the UART channel configured in software?
      i. The F280013x LaunchPad provides an option for one of two possible UART channels to be routed to the debug probe through J101. Make sure that S2 is configured to the appropriate UART channel for the application software. See Section 3.3.2 for details.

6 References

6.1 Reference Documents

In addition to this document, the following references are available for download at *www.ti.com*.

- *TMS320F2800137 C2000 Real-Time Microcontrollers*
- *TMS320F280013x C2000 Real-Time Microcontrollers*
- *TMS320F280013x C2000 Real-Time Microcontrollers Technical Reference Manual*
- *The Essential Guide for Developing with C2000™ Real-Time Microcontrollers*
- *TMS320F280013x C2000 Real-Time Microcontrollers Silicon Errata*
- *LAUNCHXL-F2800137 LaunchPad Pin Mapping*
- *C2000Ware for C2000 MCUs*
- *Application Specific Designs & Evaluation with C2000 Real-Time Microcontrollers*
- *C2000WARE Quick Start Guide*
- *Texas Instruments Code Composer Studio*
- *Texas Instruments LaunchPad Development Environment*

6.2 Other TI Components Used in This Design

This LaunchPad uses various other TI components. A consolidated list of these components with links to their TI product pages is shown.

- *MSP432E401Y SimpleLink™ 32-bit Arm Cortex-M4F MCU*
- TCAN332 *3.3 V CAN Transceiver*
- *SN74LV4053A Triple 2-Channel Analog Multiplexer/Demultiplexer IC*
- *SN74LVC2G07 Dual Buffer/Driver With Open-Drain Output*
- *TPD4E004 4-Channel ESD Protection Array for High-Speed Data Interfaces*
- *TPD4E05U06* 4-Channel ESD Protection Array for USB, HDMI & High Speed Interfaces
- *TPS3702 High-Accuracy, Fixed-Threshold OV/UV Monitor*
- *TPS7A37* 1-A, high-accuracy, ultra-low-dropout voltage regulator with reverse current protection & enable
- *SN74LVC8T245 8-Bit Dual-Supply Bus Transceiver with Configurable Voltage-Level Shifting and Three-State Outputs*

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
October 2022	*	Initial Release

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CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

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Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

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